

ELECTRONIC FUNDAMENTALS

THEORY LESSON 10

MAGNETISM AND ELECTROMAGNETISM

- 10-1. Magnets
- 10-2. Magnetism By Induction
- 10-3. Molecular Theory of Magnetism
- 10-4. Practical Magnets
- 10-5. Electricity and Magnetism
- 10-6. Magnetic Saturation



RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
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Theory Lesson 10

INTRODUCTION

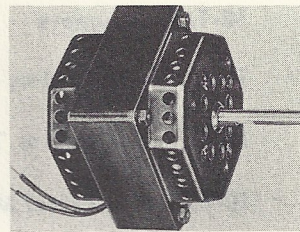
So far, your study of radio and television theory has been concerned mostly with electricity. But now, it is necessary for you to learn something about *magnetism*. Magnetism is the property of certain materials to attract iron, steel, and other similar metals. It is also the name of the study of magnets, their fields, and their actions. A *magnet* is a body that has the power to attract and hold magnetic materials such as iron, steel, nickel, cobalt, and the alloys of certain metals. A *magnetic field* is the region surrounding a magnet in which the force of the magnet affects other magnetic objects. A knowledge of magnets and their fields is important to you in your study of radio and television theory. Without it, you cannot understand how many radio and television circuits work. Unless you know something about magnetism, the theory of electric motors, generators, transformers, and loudspeakers must forever remain a mystery. Even your multimeter depends upon the action of magnetic fields. Therefore, it is clear that you must learn something about magnetism before you can continue your study of radio and television theory.

Many hundreds of years ago, it was found that pieces of a certain mineral attracted other pieces of the same mineral. This mineral also had another unusual ability. When a piece of it was suspended so that it was free to turn in any direction, one end would always come to rest pointing toward the north. The mineral was first called *lodestone*. Later, large amounts of it were found near Magnesia, a city in Asia Minor, and it came to be called *magnetite*. From this came the terms *magnet* and *magnetism*. Pieces of magnetite are sometimes called *natural magnets*, since they show magnetic

characteristics in their natural form — the form in which they are taken from the earth. However, natural magnets are not too important in our study of radio, since man-made magnets can be made much stronger.

10-1. MAGNETS

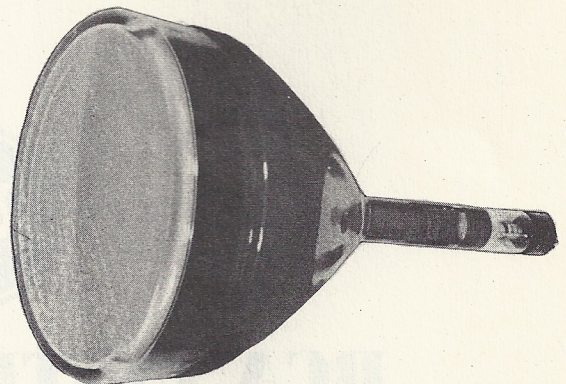
Most of the magnets used today are called *artificial magnets* because they are man-made and not natural. An artificial magnet can be made by stroking a piece of magnetic material with a piece of magnetite. Such a magnet would be very weak because the



(a) Electric Motor



(b) Loudspeaker



(c) Television Picture Tube

Fig. 10-1. Some Uses of Magnets

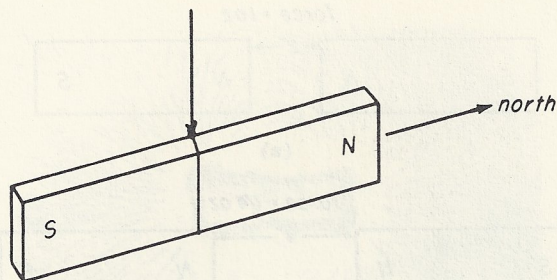


Fig. 10-2

magnetizing force of the magnetite itself is weak. A better way to make an artificial magnet would be to place a piece of magnetic material in a coil of wire that has electric current flowing through it. Using this method with special magnetic alloys, we can make very strong magnets.

Artificial magnets may be divided into two groups: *temporary magnets* and *permanent magnets*. A magnet made of iron, soft steel, or nickel will lose its magnetism almost as soon as it is removed from the magnetizing force. Such a magnet is called a temporary magnet. On the other hand, magnets made from hardened steel and modern magnetic alloys keep their magnetism for long periods of time. They are called permanent magnets.

Both temporary and permanent magnets are widely used in radio work. For example, temporary magnets are used in transformers, and relays, while permanent magnets are used in headphones, magnetic phonograph pickups, meters, and some kinds of loudspeakers.

Magnetic Poles. We said that if a magnet is suspended so that it can turn freely, one end always comes to rest pointing north. This end is called the *north-seeking pole*, or simply, the *north pole*. The other end is called the *south pole*. That free-moving bar magnets act this way can be seen by suspending a bar magnet from a string, as shown in Fig. 10-2. The pole that faces north is marked *N* and the pole that faces south is marked *S*.

You can learn another very important fact about magnets from the same suspended

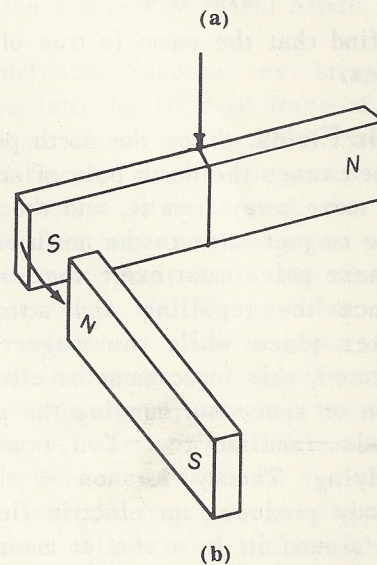
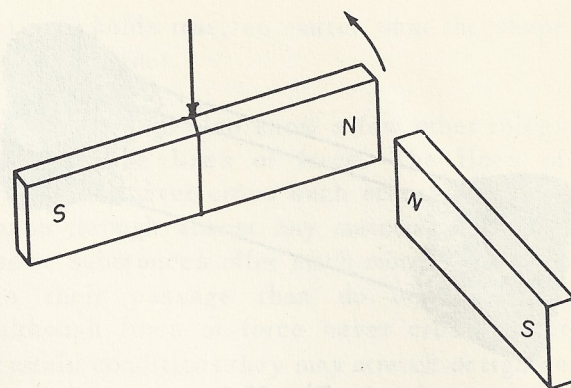


Fig. 10-3

magnet. Look at Fig. 10-3. Let's bring the north pole of another magnet close to the north pole of the suspended magnet, as in Fig. 10-3a. The north pole of the suspended magnet *moves away*; we say that it is *repelled* by the north pole of the other magnet.

If we now bring the north pole of the second magnet near the south pole of the suspended magnet, the south pole of the suspended magnet *moves nearer*; that is, it is *attracted* by the unlike pole. This is shown in Fig. 10-3b.

This is one of the most important principles of magnetism. *Like poles repel each other, and unlike poles attract each other.* This should sound familiar. Perhaps you've noticed that this law of magnetic forces is very much like the law of electrical charges. In Theory Lesson 4, you learned that like charges repel and unlike charges attract.

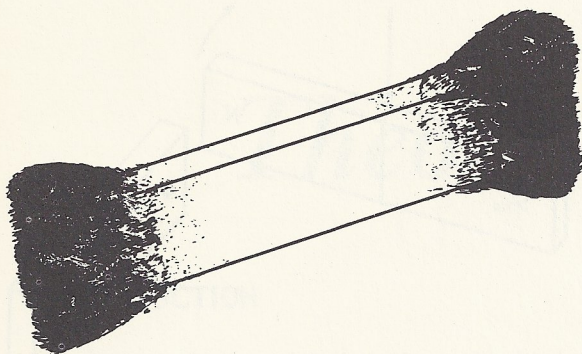


Fig. 10-4

Now you find that the same is true of magnetic forces.

Magnetic Fields. Since the north pole of one magnet causes the north pole of another magnet to move away from it, and the south pole of one magnet attracts the north pole of another, these poles must exert some sort of force. Since the repelling and attracting action takes place while the magnets are still separated, this force must be effective in a region or space surrounding the poles. This sounds familiar too. You remember from studying Theory Lesson 4 that a charged body produces an electric field in the region around it. In a similar manner, a magnet produces a magnetic field, which we have defined as the region surrounding a magnet in which its force affects other magnetic objects.

We can get an idea of this magnetic field by dipping a bar magnet into a jar of iron filings. The filings cling to the ends of the magnet in clusters, as shown in Fig. 10-4, with hardly any filings near the center of the bar. This shows that the magnetic strength — or *field strength* — of a bar magnet is greatest at its poles and least at the center of the bar. If we could measure this very carefully, we would find that it is exactly the same at each pole.

Now we come to another very important principle of magnetism. We know that like poles repel and unlike poles attract. The strength with which they attract or repel each other depends not only on the strength of their poles, but also upon the distance between them. For example, in Fig. 10-5a,

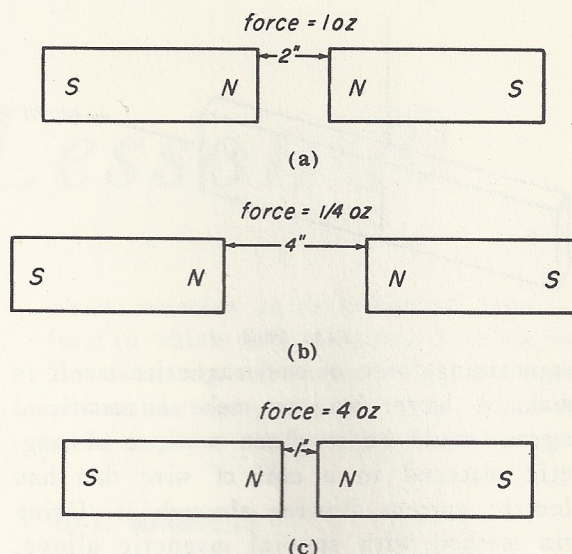
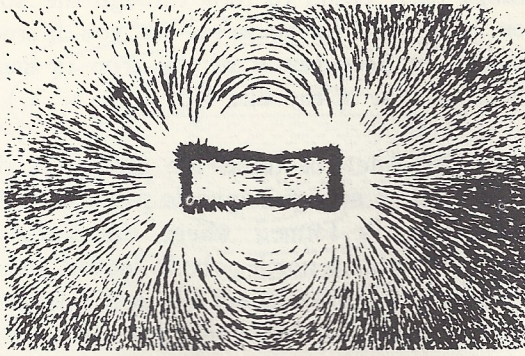


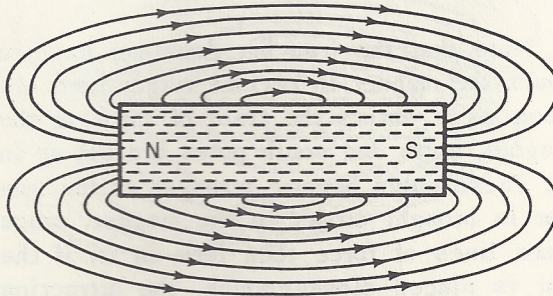
Fig. 10-5

two bar magnets are placed so that their poles are 2 inches apart. Let's suppose that in this position, the two bar magnets repel each other with a force of 1 ounce. If the magnets are moved away from each other until they are 4 inches apart, as shown in Fig. 10-5b, the repelling force will be only 1/4 ounce; if the magnets are moved toward each other so that their poles are only 1 inch apart, as in Fig. 10-5c, the repelling force will be 4 ounces, or four times as great as it was when the magnets were 2 inches apart. You can see that the strength of the magnetic field decreases when the poles are farther from each other.

Lines of Force. The pattern of the field of force exerted by a magnet can be seen by placing a sheet of paper, cardboard, or glass over a bar magnet and sprinkling iron filings on it. If the sheet is tapped gently, the iron filings arrange themselves into a definite pattern, as shown in Fig. 10-6a. This is what happens. Each iron filing becomes magnetized when it enters the field of force of the bar magnet. Hundreds of tiny magnets are thus created. These magnetized filings line themselves end to end and form many curved lines. In part b of the figure, the lines extending from one pole of the magnet to the other are redrawn. These lines represent the magnetic force exerted by the bar magnet, and are called *lines of force*, or *flux lines*.



(a)



(b)

Fig. 10-6

The lines of force also show the general direction of magnetic force. We can see that the lines tend to spread outward from each pole and travel in loops to the other pole. Still another characteristic of lines of force can be seen by the use of a compass, as shown in Fig. 10-7. If you place a compass at different points around a bar magnet, and note the direction in which the needle points at each position, you will find that the needle follows the lines of force. The lines begin at the north pole of the magnet and travel in a loop to the south pole. So, we say that the direction of any line of force is from the north pole to the south pole. This

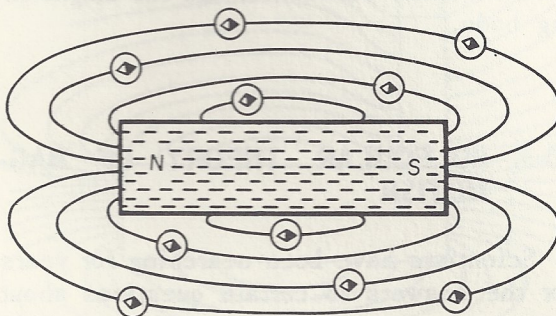


Fig. 10-7

always holds true, no matter what the shape of the magnet.

You should also know a few other things about these lines of force. The lines of force can never cross each other. They can pass through almost any material, although some substances offer much more opposition to their passage than do others. Also, although lines of force never cross, under certain conditions they may stretch or tighten much like a bunch of rubber bands.

Reluctance. Suppose we bring a soft-iron bar into the field of force of the first magnet, as shown in Fig. 10-8. Some of the lines of force of the first magnet now change their paths to pass through the iron bar. They do this because a magnetic substance offers less opposition to the formation of flux lines than air. We say that air has a higher *reluctance* than magnetic materials because it has greater opposition to flux lines. Sometimes we express this the other way around, in terms of which material offers less opposition to lines of force than air. We then use the term *permeability*, which is a measure of the ease with which lines of force can form in a material. Air, therefore, has a low permeability, which is the same as saying that it has a high reluctance. The permeability of all materials is compared with that of air. So, we say that air has a permeability of 1. The permeability of non-magnetic materials is the same as that of air, while some magnetic alloys have permeabilities thousands of times as great as that of air.

What would happen to the lines of force if, instead of an iron bar, we brought another

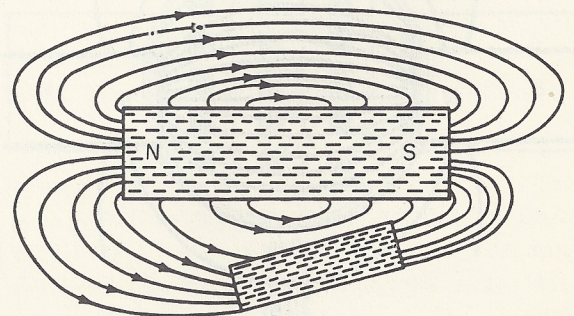


Fig. 10-8

magnet into the magnetic field? Figure 10-9a shows that when the north poles of two magnets are brought near each other, the lines of force from one north pole seem to push away from those of the other north pole. Part b of the figure shows what happens when unlike poles are brought near to each other. The lines of force seem to tighten between the two poles, drawing them closer. This, of course, is in keeping with what you already know — that like poles repel and unlike poles attract.

10-2. MAGNETISM BY INDUCTION

Now that we know something about the field of force that surrounds a magnet, we can get a better idea of how magnetic materials may be magnetized. Figure 10-10a shows the lines of force around a bar magnet. Suppose that we bring a bar of soft iron near the magnet. Part b of the figure shows that some of the lines of force of the magnet

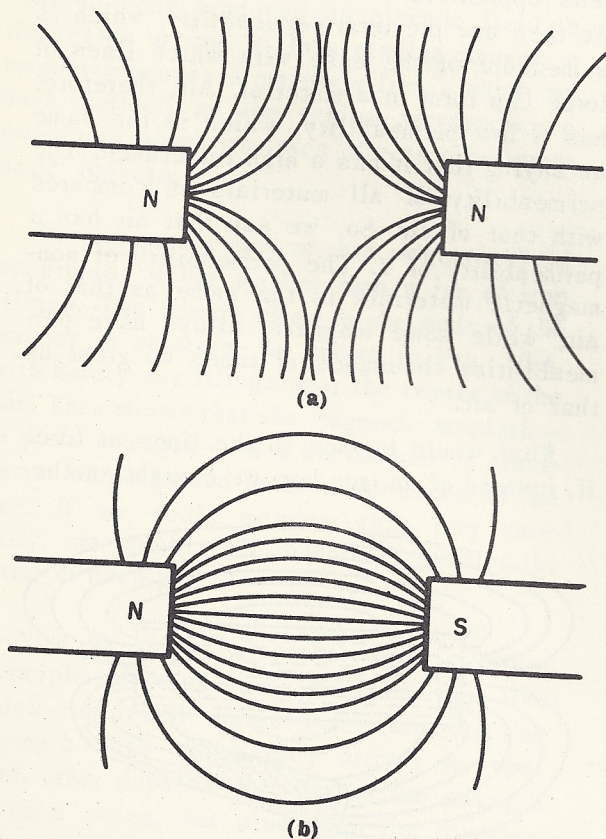


Fig. 10-9

change their paths to form through the soft-iron bar. This is because, as you learned before, the reluctance of the iron is much less than that of the air.

As the lines of force are formed in the iron bar, they set up magnetic poles in it. A south pole is formed where the lines of force enter, and a north pole is formed where they leave. This bears out our description of lines of force — that they always have a direction away from the north pole of a magnet and toward the south pole.

Note that the iron bar does not have to touch the magnet to become magnetized. As soon as it enters the field of force of the magnet, north and south poles are set up in it. These poles become stronger as the iron bar is brought closer to the magnet, since more lines of force then form in it. If the bar is placed close enough, the attraction between the two unlike poles will cause the bar to be drawn to the magnet, as in part c of the figure. In part d, another iron bar is added. It, too, becomes magnetized as the lines of force pass through it. Note the polarity of the bars; the magnetic lines still point toward the south poles and away from the north poles.

When a magnetic material is magnetized by being brought close to a magnet, we say that it is magnetized by *induction*. This simply means that magnetism is *induced* or *set up* in the magnetic material without it actually touching the magnet. A magnetic material can be magnetized by touching it or rubbing it against a magnet. This means that the material is magnetized by means of actual contact between it and the magnetizing body.

10-3. MOLECULAR THEORY OF MAGNETISM

Scientists have been searching for years for the answers to certain questions about the way magnets and magnetic materials behave. They have come up with many ideas

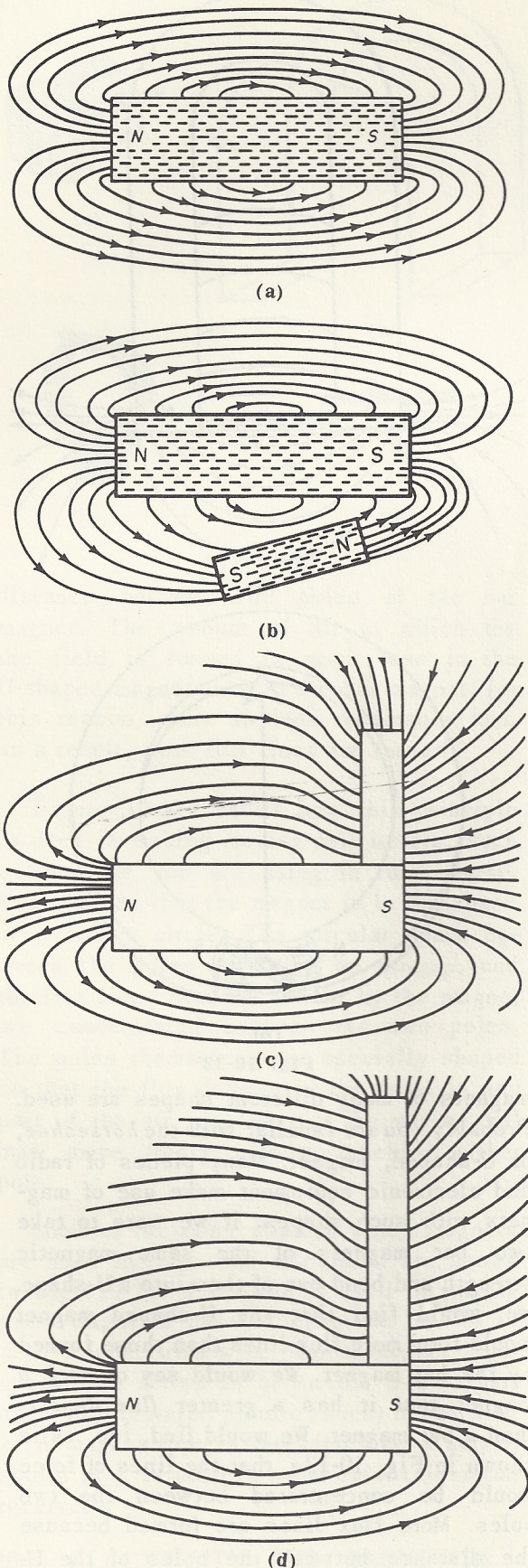


Fig. 10-10

and theories about what happens in a piece of magnetic material when it is being magnetized. Among them, there is one called Weber's Theory, which is also known as the *molecular theory of magnetism*.

According to this theory, each molecule of a magnetic material acts like a tiny magnet. If we break up a permanent magnet into very small pieces without heating or jarring them, we find that each small piece forms a magnet with its own north and south poles. It is believed that were we to continue to break up such a magnet into its molecules, we would find that each molecule would be a tiny magnet. Before the material is magnetized, these tiny magnetic molecules are arranged so that their poles point in all possible directions, as shown in Fig. 10-11a. When a magnetic substance is magnetized, the molecules are forced by the magnetizing field to arrange themselves in the direction of the flux (lines of force) of the field. As a result, a piece of magnetic material that is completely magnetized has

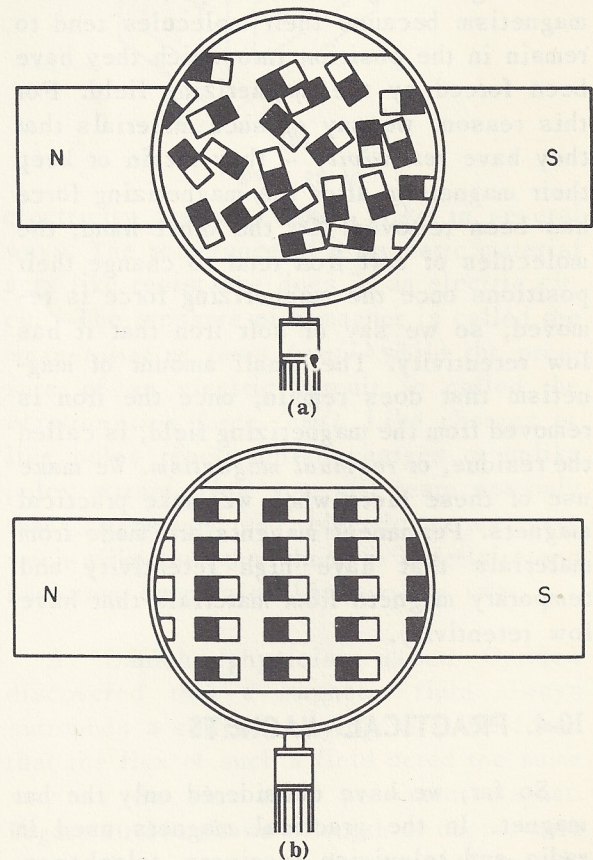


Fig. 10-11

all of its molecules arranged in an orderly manner, as shown in Fig. 10-11b. If the magnetizing force is weak, only a few of the molecules will arrange themselves in the direction of the magnetizing field. More molecules are arranged in this manner as the intensity of the field is increased, until the point is reached when all of the molecules of the magnetic material have arranged themselves in the direction of the magnetizing field. When this point is reached, we call it *saturation*. Then, no matter how much the magnetizing field may be increased, there is no further change in the arrangement of molecules.

Hard steel and magnetic alloys, such as Alnico and Permalloy, require a very intense field to magnetize them, because their molecules do not turn easily. A piece of soft iron, because its molecules turn more easily than do those of the harder magnetic materials, may be magnetized with a much weaker magnetizing force. However, when the hard steel and magnetic alloys are removed from the magnetizing field, they retain their magnetism because their molecules tend to remain in the position into which they have been forced by the magnetizing field. For this reason, we say of such materials that they have *retentivity* — they retain or keep their magnetism after the magnetizing force has been removed. On the other hand, the molecules of soft iron tend to change their positions once the magnetizing force is removed; so we say of soft iron that it has low retentivity. The small amount of magnetism that does remain, once the iron is removed from the magnetizing field, is called the residue, or *residual magnetism*. We make use of these facts when we make practical magnets. Permanent magnets are made from materials that have high retentivity and temporary magnets from materials that have low retentivity.

10-4. PRACTICAL MAGNETS

So far, we have considered only the bar magnet. In the practical magnets used in radio and television receivers, telephones, moving-coil meters, and similar equipment,

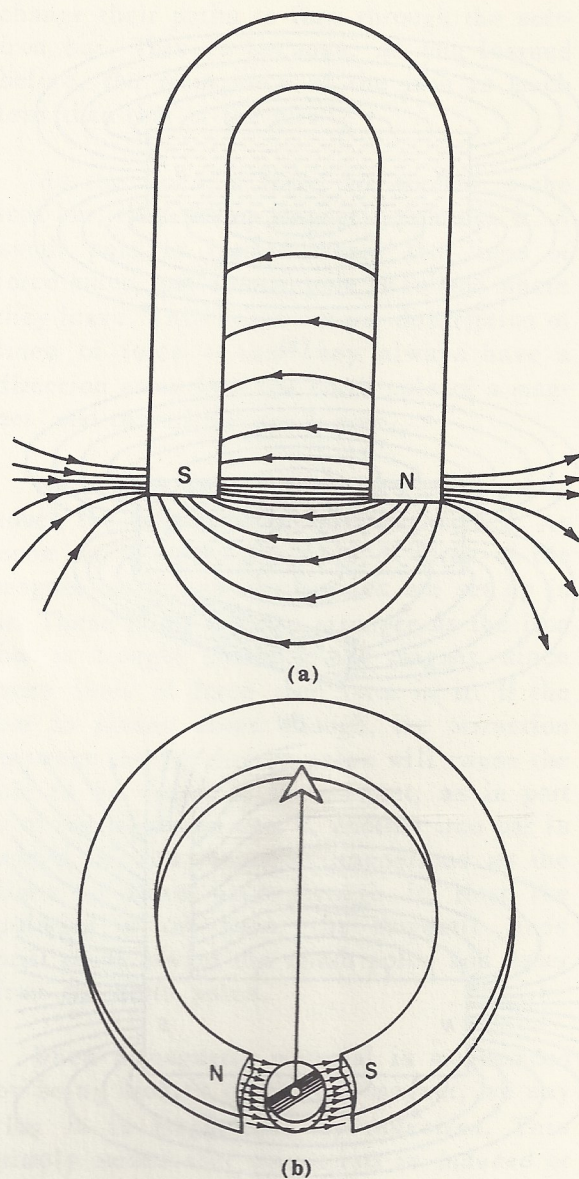


Fig. 10-12

magnets of many different shapes are used. Probably you are familiar with the *horseshoe*, or U-shaped, magnet. Many pieces of radio and electronic equipment make use of magnets with such shapes. If we were to take two bar magnets of the same magnetic strength and bend one of them into a U-shape, we would find that the U-shaped magnet would form more flux lines than those formed by the bar magnet. We would say of such a magnet that it has a greater *flux density* than a bar magnet. We would find, too, as is shown in Fig. 10-12a, that the lines of force would be concentrated between the two poles. More flux lines are formed because the distance between the poles of the U-shaped magnet is much shorter than the

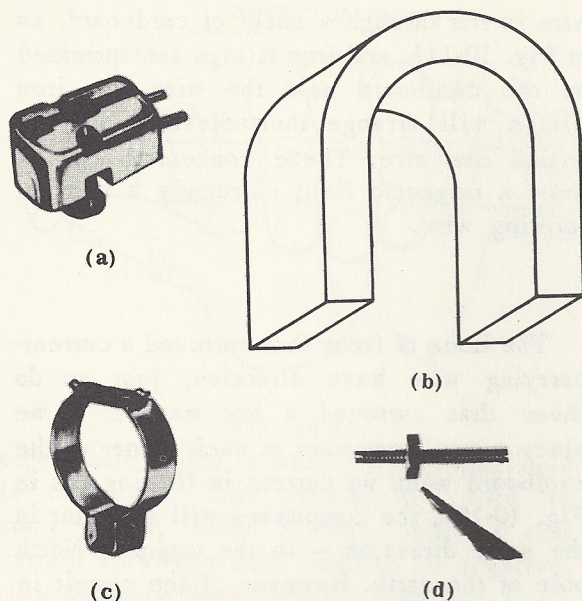


Fig. 10-13

distance between the poles of the bar magnet. The amount of air in which the field is formed is much less in the U-shaped magnet than in the bar magnet; for this reason, there is less reluctance and, as a result, more flux lines are formed.

Figure 10-12*b* shows how this principle is used in making moving-coil meters, such as the one you are using in this course. You can see that the magnet is in the shape of a broken circle. The circular space between the poles is called an *air-gap*, and the flux lines that are formed by the magnet are concentrated between the two poles. The poles themselves are specially shaped so that the flux density is the same in any part of the air gap, so that the moving coil may move freely without touching either pole.

Some of the many ways in which magnets are used in radio and television are shown in Fig. 10-13. A magnet is used in making some magnetic phono pickups as shown in *a*. A magnet from a permanent-magnet loud-speaker is shown in *b*. An *ion trap* (a part used on television picture tubes) appears in *c*. A magnet that is threaded like a screw, shown in *d*, is used in some color television receivers.

10-5. ELECTRICITY AND MAGNETISM

You have seen that magnetism and

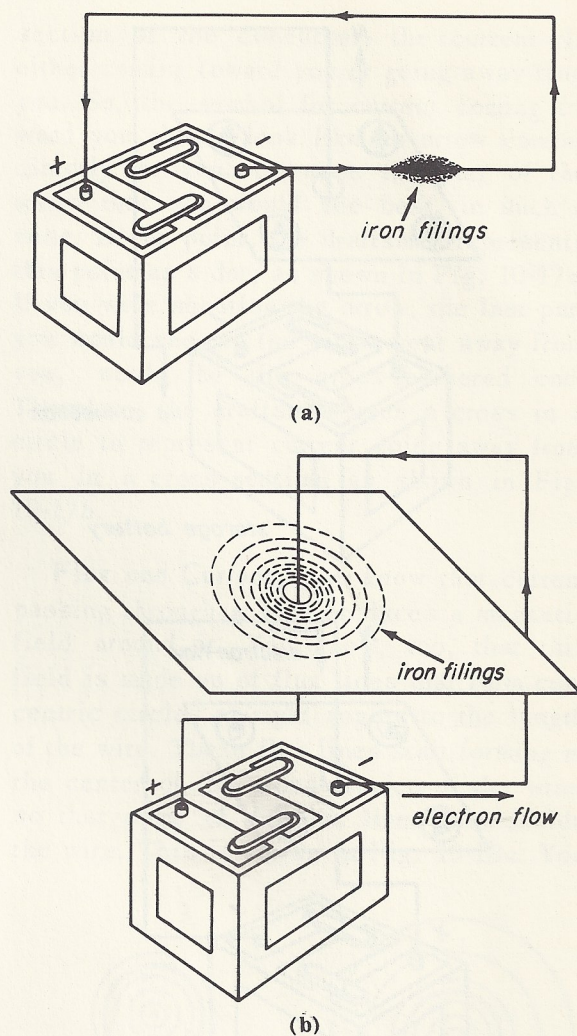


Fig. 10-14

electricity are very much alike in several ways. The reluctance of a magnetic material acts like resistance does in an electric circuit. The pressure of a magnet is called the *magnetomotive force (mmf)*, while the pressure of an electric circuit is called the *electromotive force (emf)*. Like charges or like poles repel; unlike charges or unlike poles attract. Now you will learn not only that magnetism and electricity are very much alike, but that there is a definite and important connection between the two.

A Danish physicist named Oersted discovered that a magnetic field always surrounds a current-carrying wire. He found that the flux of such a field acted the same way as the flux of a permanent magnet. Figure 10-14*a* shows a length of copper wire attached to a storage battery and brought near a pile of iron filings. It attracts iron filings just as does a bar magnet. If the

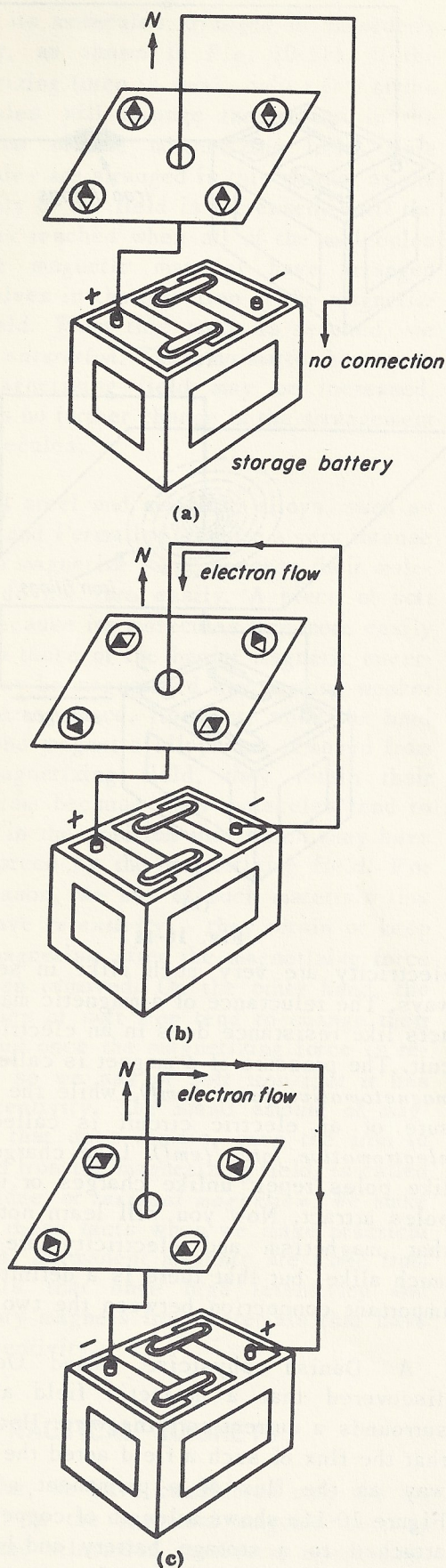


Fig. 10-15

wire is run through a sheet of cardboard, as in Fig. 10-14b, and iron filings are sprinkled on the cardboard near the wire, the iron filings will arrange themselves in circles around the wire. These concentric circles show a magnetic field surrounds a current-carrying wire.

The lines of force that surround a current-carrying wire have direction, just as do those that surround a bar magnet. If we place a small compass at each corner of the cardboard when no current is flowing, as in Fig. 10-15a, the compasses will all point in the same direction — to the magnetic North pole of the earth. However, if the circuit is completed, as in Fig. 10-15b, the compasses will point in the direction of the flux lines set up by the current flowing in the wire. We can be sure that the magnetic field is there because if we open the circuit, the compasses will again all point north.

Now suppose we reverse the connections to the battery — that we make the current flow in the other direction, as in Fig. 10-15c. The compasses again point in the direction of the flux lines. However, the direction of flux is opposite to that in Fig. 10-15b. This means that the direction of the magnetic field around a current-carrying wire depends on the direction of the current.

Left-Hand Rule. An easy way to find out the direction of the flux lines is to use the *left-hand rule*, as shown in Fig. 10-16. Grasp the current-carrying wire in your left hand, with your thumb pointing in the direction of electron (current) flow. Your fingers will then point in the direction of the flux lines. This rule also works the other way; if you know the direction of the lines of force, you can tell the direction of the current flow. To do this, grasp the conductor with your left hand, with your fingers pointing in the direction of the flux lines. Your thumb will then point in the direction of the current flow.

It is possible that you may find some

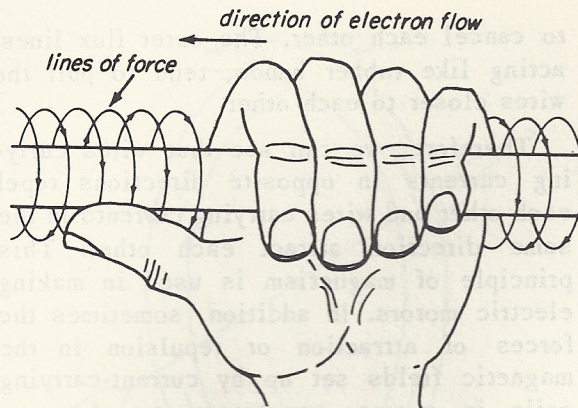


Fig. 10-16

older radio books in which a *right-hand rule* is explained. This method was used for many years, when it was believed that current flow was from positive to negative. Now we know that electrons flow from negative to positive; we use the left-hand rule:

Symbols for Current Flow. You know that we may show direction of current flow either by means of arrows running parallel with circuits or by drawing arrow heads on lines representing circuits. Sometimes, it is necessary to show the direction of current flow in a cross-sectional view of a wire. In drawings of this kind, we use two special symbols to represent the direction of current flow. In a drawing where you see the cross

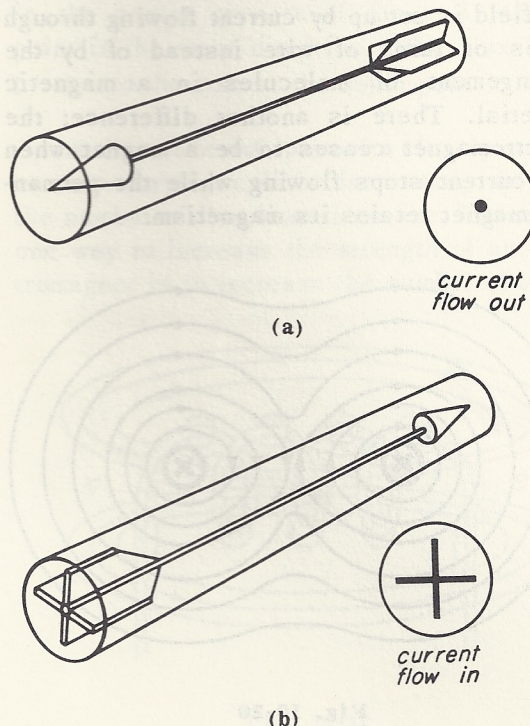


Fig. 10-17

section of the conductor, the current is either coming toward you or going away from you. So, the symbol for current coming toward you should look like an arrow coming directly at you. Because the part of the arrow that you would see best, in such a case, is the point, the draftsman represents this point as a dot, as shown in Fig. 10-17a. If you were shooting the arrow, the last part you would see, as the arrow went away from you, would be the cross-feathered end. Therefore, the draftsman uses a cross in a circle to represent current going away from you in a cross-section, as shown in Fig. 10-17b.

Flux and Current. You know that current passing through a wire produces a magnetic field around it. You know, too, that this field is made up of flux lines that form concentric circles at right angles to the length of the wire. These flux lines start forming at the center of the cross-section of the wire, so that some of the flux lines form inside the wire. This is shown in Fig. 10-18a. You

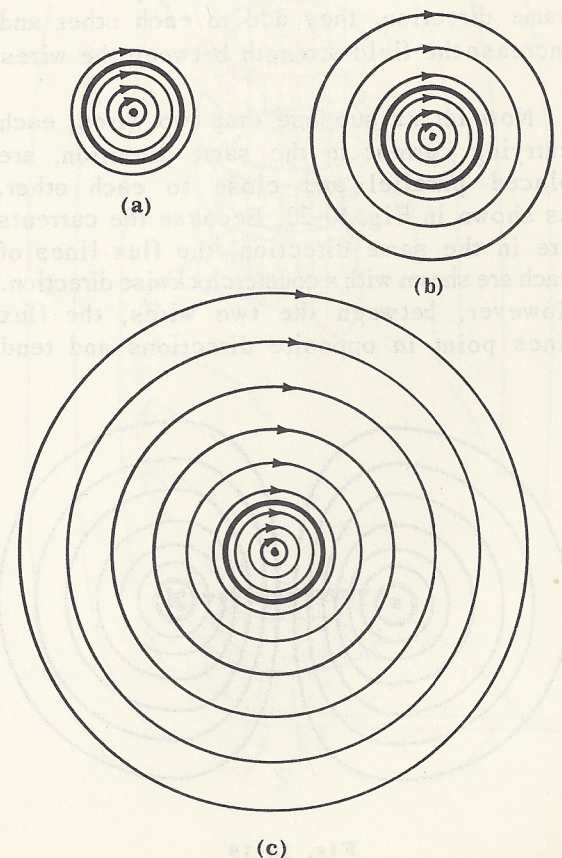


Fig. 10-18

see a cross-section of a wire with current flowing toward you. This being so, the flux lines have a clockwise direction. If the current is increased, as in Fig. 10-18b, more flux lines are formed, and the field spreads out from the wire. If the current is still further increased, as in Fig. 10-18c, the field expands also. From this, you can see that the greater the current that flows through a wire, the greater is the magnetic field.

Flux and Parallel Wires. Suppose that two wires, each carrying current in a direction opposite to the other, are placed parallel and close to each other. Each wire will have its own field, as shown in Fig. 10-19. Because the currents are opposite in direction, the flux lines, too, are opposite; one field is clockwise and the other field is counterclockwise. However, *between the two conductors*, the flux lines of both conductors point in the same direction. Flux lines pointing in the same direction tend to push away from each other, so flux lines between the wires repel each other. Because the flux lines between the wires point in the same direction, they add to each other and increase the field strength between the wires.

Now let us suppose that two wires, each carrying current in the same direction, are placed parallel and close to each other, as shown in Fig. 10-20. Because the currents are in the same direction, the flux lines of each are shown with a counterclockwise direction. However, between the two wires, the flux lines point in opposite directions and tend

to cancel each other. The outer flux lines, acting like rubber bands, tend to pull the wires closer to each other.

Therefore, we can see that wires carrying currents in opposite directions repel each other and wires carrying currents in the same direction attract each other. This principle of magnetism is used in making electric motors. In addition, sometimes the forces of attraction or repulsion in the magnetic fields set up by current-carrying coils in motors, generators, transformers, and other electric equipment is so great that damage to equipment may occur when currents are suddenly increased by short circuits or other causes.

Flux and a Current-Carrying Loop. We have seen that a magnetic field exists around a length of current-carrying wire. Now suppose that we bend the current-carrying wire to form a loop, as shown in Fig. 10-21. The drawing shows that all the flux lines point *into* the loop on one side and *out of* the loop on the other side. This is like a permanent magnet, in which the flux points into the south pole and out of the north pole. So, by forming the wire into a loop, we produce an *electromagnet* with a north pole and a south pole. An electromagnet differs from a permanent magnet in that its field is set up by current flowing through loops or turns of wire instead of by the arrangement of molecules in a magnetic material. There is another difference; the electromagnet ceases to be a magnet when the current stops flowing while the permanent magnet retains its magnetism.

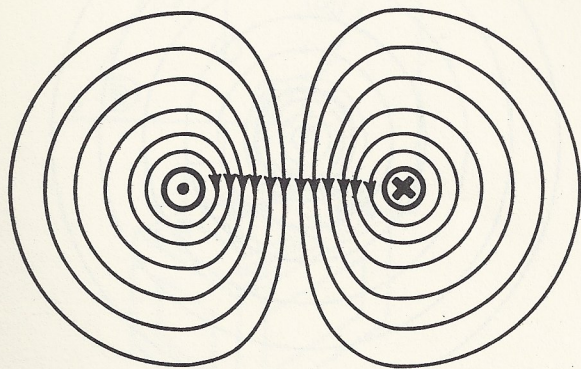


Fig. 10-19

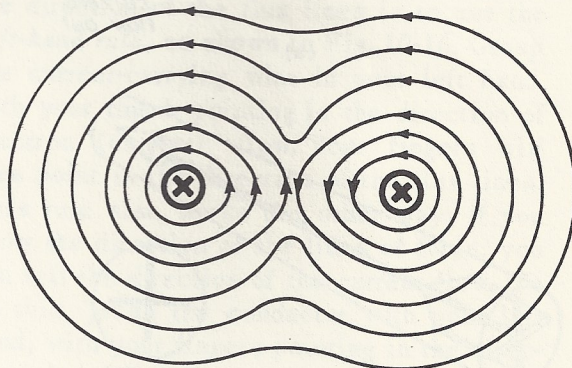


Fig. 10-20

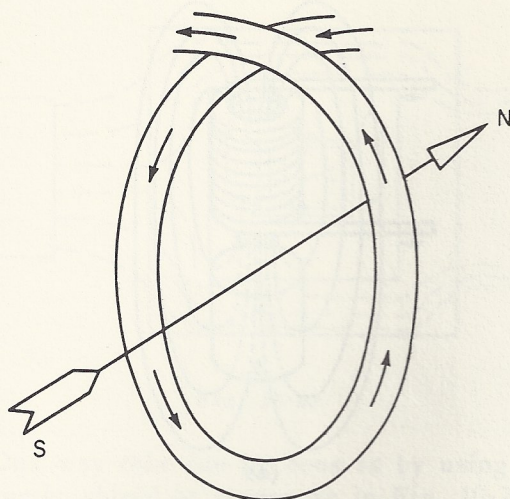


Fig. 10-21

Flux and Turns of a Current-Carrying Coil.

A single turn of wire does not produce a very strong magnet, so practical electromagnets are normally made from many turns of wire. Figure 10-22 shows a current-carrying coil of four turns. Each turn is parallel to the next one, so the effect is the same as having parallel current-carrying wires. If the turns are close together, only few flux lines form between the turns, and these lines cancel each other. The outer flux lines of each turn link together to form the field around the coil. The flux lines concentrate in the center or *core* of the coil, and all point in the same direction. The flux lines point into the core at the south pole.

As the number of turns of a closely-wound, current-carrying coil is increased, so does the number of flux lines increase. Therefore, one way to increase the strength of an electromagnet is to increase the number of turns.

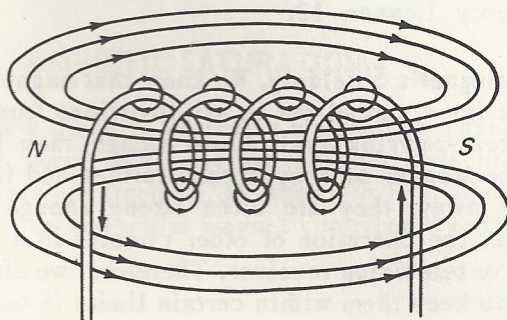


Fig. 10-22

Left-Hand Rule for a Current-Carrying Coil. The magnet polarity of a coil can be found by the *left-hand coil rule*, illustrated in Fig. 10-23. Grasp the coil with your left hand with your fingers pointing in the direction of current flow. Your thumb will then point in the direction of the coil's north pole.

Flux and the Core Material. You know that the magnetic flux of a current-carrying coil can be increased by increasing the current flowing through the coil or by increasing the number of turns in the coil. A third way in which the flux can be increased is by winding the coil around a core material that has a higher permeability than that of air. A coil with a soft-iron core, for instance, produces a much stronger field than an air-core coil of the same number of turns. A core made of powdered iron that has been pressed together may have a permeability of from

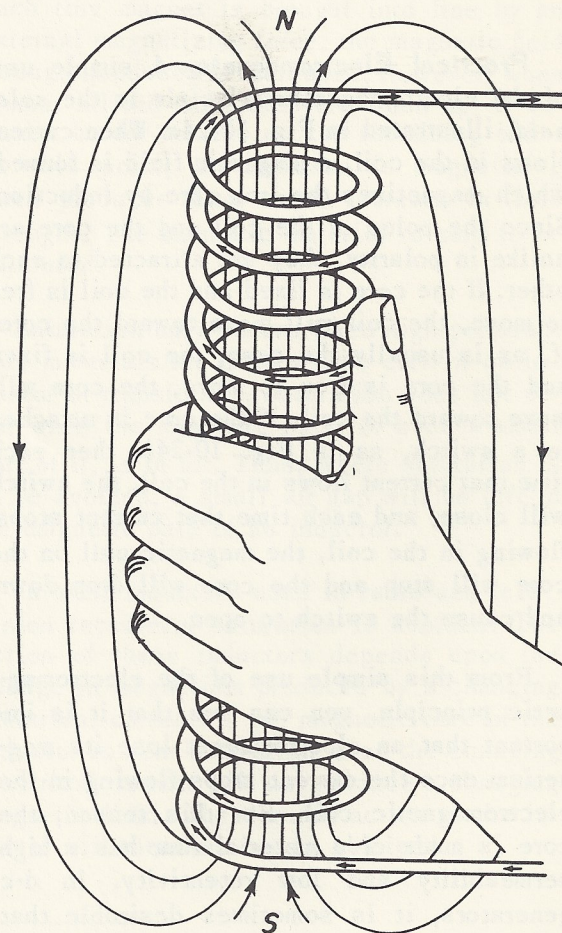


Fig. 10-23

50 to 100 times that of air. Radio and television coils that use such cores form many times the number of flux lines that a similar air-core coil might form. Other materials, known as *ferrites*, have a permeability of well over 1,000. They are also used in radio and television coils.

We can see that the strength of an electromagnet depends mainly on three things:

1. The amount of current flowing in the coil; the greater the current, the greater is the magnetic flux.
2. The number of turns in the coil; the greater the number of evenly spaced turns, the greater is the magnetic flux.
3. The permeability of the core material; the greater the permeability, the greater is the magnetic flux.

Practical Electromagnets. A simple use of the electromagnetic principle is the *solenoid*, illustrated in Fig. 10-24a. When current flows in the coil, a magnetic field is formed, which magnetizes the iron core by induction. Since the poles of the coil and the core are unlike in polarity, they are attracted to each other. If the core is fixed and the coil is free to move, the coil will move toward the core. If, as is usually the case, the coil is fixed and the core is free to move, the core will move toward the coil. If the core is attached to a switch, as in Fig. 10-24b, then each time that current flows in the coil, the switch will close, and each time that current stops flowing in the coil, the magnetic pull on the core will stop and the core will drop down and cause the switch to open.

From this simple use of the electromagnetic principle, you can see that it is important that an electromagnet lose its magnetism once the current stops flowing in the electromagnetic coil. For this reason, the core is made of a material that has a high permeability and low retentivity. In d-c generators, it is sometimes desirable that a magnetic core retain some of its magnetism; so, in such cases, the core is made of

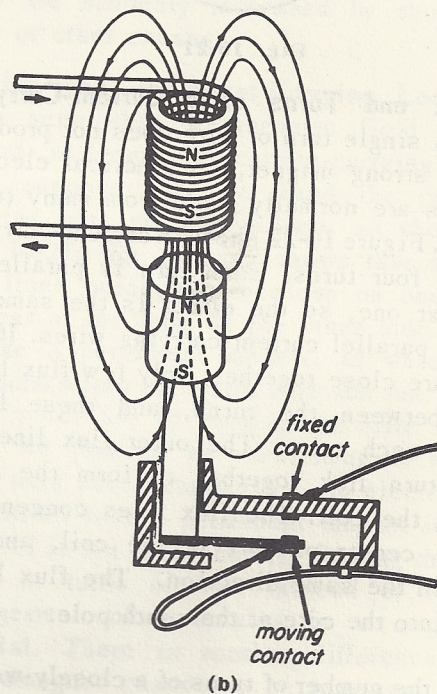
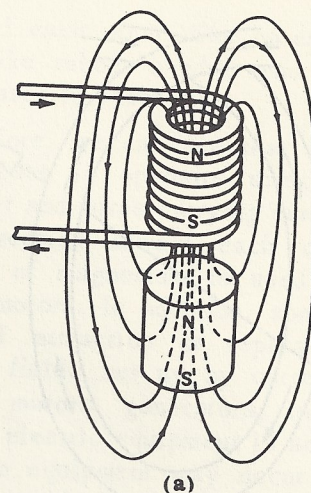


Fig. 10-24

a material that will hold some of its magnetism after the current stops flowing in the coil. This is discussed more completely in Theory Lesson 12.

Magnetic Shielding. We know that magnetic flux lines spread out in all directions from a current-carrying coil. Even though they become weaker as they spread farther and farther away, they are often strong enough to upset the operation of other circuits in a radio or television receiver. Therefore, we often try to keep them within certain limits in order to prevent them from spreading too far and interfering with other circuits.

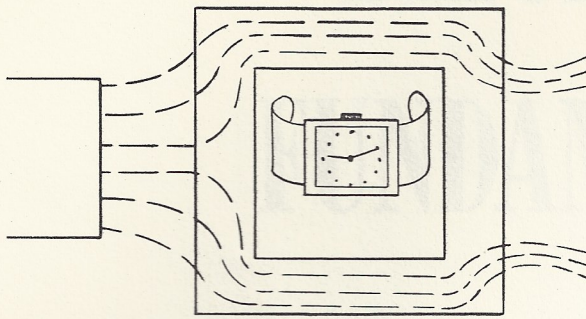


Fig. 10-25

One way this can be done is by using a magnetic shield or screen as in Fig. 10-25. This is usually a case or can of soft iron. Since flux lines form in a magnetic material more easily than in air, most of them will form in the shield. A shield is necessary to keep some components isolated from the magnetic field around other components.

Demagnetizing. Sometimes a tool, a watch, or some other instrument becomes magnetized by accident. When this happens, it is necessary to know how to *demagnetize* whatever has become accidentally magnetized. By demagnetizing, we mean the removal of the magnetism and the restoration of the article to its original condition. The simplest way to do this is to place the watch or other article in the field set up by an alternating current. For example, you can use a 1,000- to 3,000 ohm field coil from an old electrodynamic speaker connected to an a-c supply, as shown in Fig. 10-26. Place the watch in or near the center (core) of the coil. Then move the watch very slowly away from coil and its field. Do not try to rush the movement away from the a-c field or you will have to do the demagnetizing all over again.

10-6. MAGNETIC SATURATION

As a piece of magnetic material is magnetized, more and more of the tiny molecular magnets are lined up, as shown in Fig. 10-11. Each tiny molecular magnet contributes to the

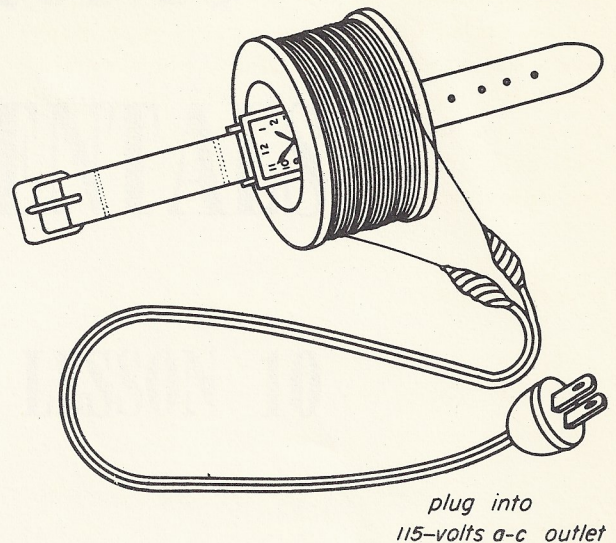


Fig. 10-26

field strength of the total magnet. Thus, as each tiny magnet is brought into line by an external magnetizing force, the magnetic field strength produced is increased. However, when almost all the molecules are lined up, it becomes harder to line up the remaining ones. At this point, an increase in magnetizing force produces little or no increase in field strength. The magnetic material is said to be *saturated*.

Saturation only occurs when high permeability materials are used as the core of an inductor or transformer. Saturation does not occur when the magnetic path, or even a small part of it, is in air. Thus, where saturation is to be avoided, a small air gap will be left in the magnetic path of an inductor.

In most inductors used in radio and television receivers, saturation is avoided. The action of these inductors depends upon the change in magnetism produced by a changing electrical current. If the magnetic core of the inductor is near saturation, then the changing electrical current will not produce a changing magnetic field. The desired action of the inductor will therefore not be obtained.